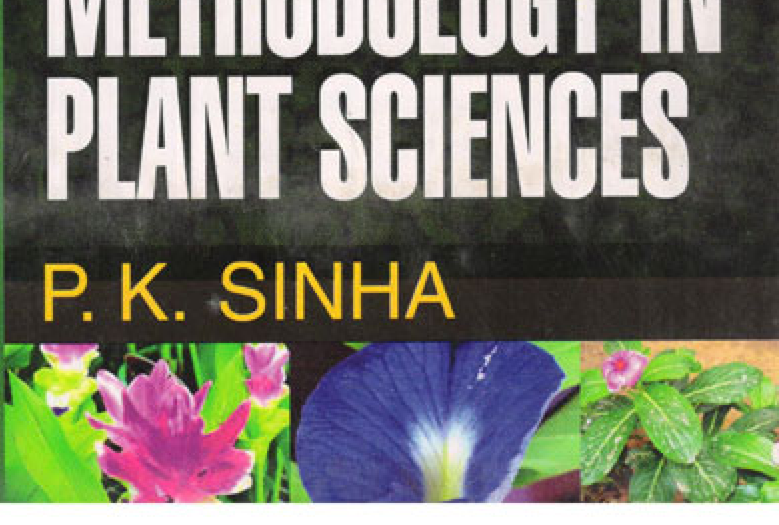
RESEARCH METHODOLOGY IN PLANT SCIENCES

P. K. SINHA



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PREFACE

This book will emphasize the physiological and biochemical functions of plants, but it is important to recognize that these functions depend on structures, whether the process is gas exchange in the leaf, water conduction in the xylem, photosynthesis in the chloroplast, or ion transport across the plasma membrane. At every level, structure and function represent different frames of reference of a biological unity. This chapter provides an overview of the basic anatomy of plants, from the organ level down to the ultrastructure of cellular organelles. In subsequent chapters we will treat these structures in greater detail from the perspective of their physiological functions in the plant life cycle. The increasing complexity of horticultural problems forces scientists in horticulture to modify their conception of the systems they work with and the methods for analysing and solving problems and designing solutions. It does so by creating bridges between cell and crop physiologists, between horticulturists and crop physiologists and indeed joins expertise of such widely diverging disciplines like computer science, farm economics, control engineering, crop protection, botany, etc. Obviously, this approach represents a major development in the tradition of horticultural sciences, with great potentials in many areas, including education.

Although cases do exist where only one small element represents a major bottleneck, modern horticultural production systems are, in general, characterised by intricate relationships and a high level of development, where improvements are only realised by sophisticated and well balanced modifications of the system and subsequent fine-tuning of the adapted production system. In addition problems encountered nowadays in the horticultural industry often result from interactions with the outside world: the role of the market, the consumers and environmental issues can no longer be ignored. In this constellation methods to analyse and handle complex systems are indispensable. A system approach, based on models of various degrees of complexity and at various levels of integration, has proved its potential to deal with this kind of problems. Models of greenhouses, crops, pests, as well as tools based on such models enable scientists of different disciplines to join forces and to re-use knowledge generated within another context, for another crop, or another situation. The systems approach adds a new dimension to horticultural science, because it replaces in many cases empiricism with disciplinary knowledge.

—*Author*

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OVERVIEW OF PLANT STRUCTURE

INTRODUCTION

The primary function of a leaf is photosynthesis, that of the stem is support, and that of the root is anchorage and absorption of water and minerals. Leaves are attached to the stem at nodes, and the region of the stem between two nodes is termed the internode. The stem together with its leaves is commonly referred to as the shoot. Despite their apparent diversity, all seed plants have the same basic body plan. The vegetative body is composed of three organs: leaf, stem, and root. There are two categories of seed plants: gymnosperms (from the Greek for "naked seed") and angiosperms (based on the Greek for "vessel seed," or seeds contained in a vessel). Gymnosperms are the less advanced type; about 700 species are known. The largest group of gymnosperms is the conifers ("cone-bearers"), which include such commercially important forest trees as pine, fir, spruce, and redwood. Angiosperms, the more advanced type of seed plant, first became abundant during the Cretaceous period, about 100 million years ago. Today, they dominate the landscape, easily outcompeting the gymnosperms. About 250,000 species are known, but many more remain to be characterized. The major innovation of the angiosperms is the flower; hence they are referred to as flowering plants.

Cell Walls

A fundamental difference between plants and animals is that each plant cell is surrounded by a rigid cell wall. In animals, embryonic cells can migrate from one location to another, resulting in the development of tissues and organs containing cells that originated in different parts of the organism.

In plants, such cell migrations are prevented because each walled cell and its neighbor are cemented together by a middle lamella. As a consequence, plant development, unlike animal development, depends solely on patterns of cell division and cell enlargement.

Plant cells have two types of walls: primary and secondary. Primary cell walls are typically thin (less than 1 ¼m) and are characteristic of young, growing cells. Secondary cell walls are thicker and stronger than primary walls and are deposited when most cell enlargement has ended. Secondary cell walls owe their strength and toughness to lignin, a brittle, gluelike material.

The evolution of lignified secondary cell walls provided plants with the structural reinforcement necessary to grow vertically above the soil and to colonize the land. Bryophytes, which lack lignified cell walls, are unable to grow more than a few centimeters above the ground.

Tissues Meristems

Plant growth is concentrated in localized regions of cell division called meristems. Nearly all nuclear divisions (mitosis) and cell divisions (cytokinesis) occur in these meristematic regions. In a young plant, the most active meristems are called apical meristems; they are located at the tips of the stem and the root. At the nodes, axillary buds contain the apical meristems for branch shoots. Lateral roots arise from the pericycle, an internal meristematic tissue. Proximal to (i.e., next to) and overlapping the meristematic regions are zones of cell elongation in which cells increase dramatically in length and width. Cells usually differentiate into specialized types after they elongate.

The phase of plant development that gives rise to new organs and to the basic plant form is called primary growth. Primary growth results from the activity of apical meristems, in which cell division is followed by progressive cell enlargement, typically elongation. After elongation in a given region is complete, secondary growth may occur. Secondary growth involves two lateral meristems: the vascular cambium (plural cambia) and the cork cambium. The vascular cambium gives rise to secondary xylem (wood) and secondary phloem. The cork cambium produces the periderm, consisting mainly of cork cells.

Three Major Tissue Systems Make Up the Plant Body Three major tissue systems are found in all plant organs: dermal tissue, ground tissue, and vascular tissue.

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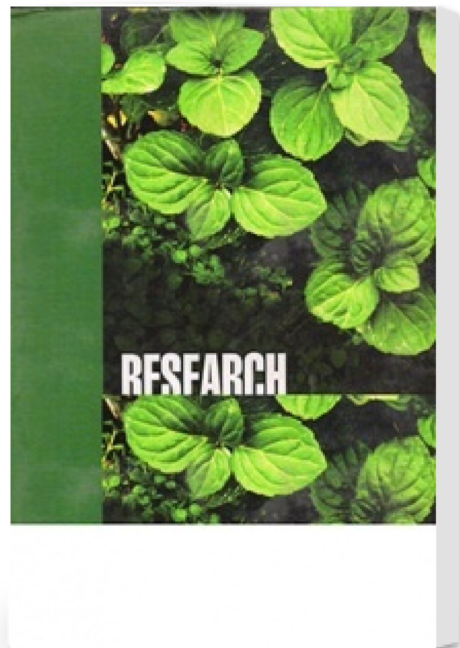

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